# Introduction to Biofuels

**Course Number:** CH-02-110

**PDH:** 3

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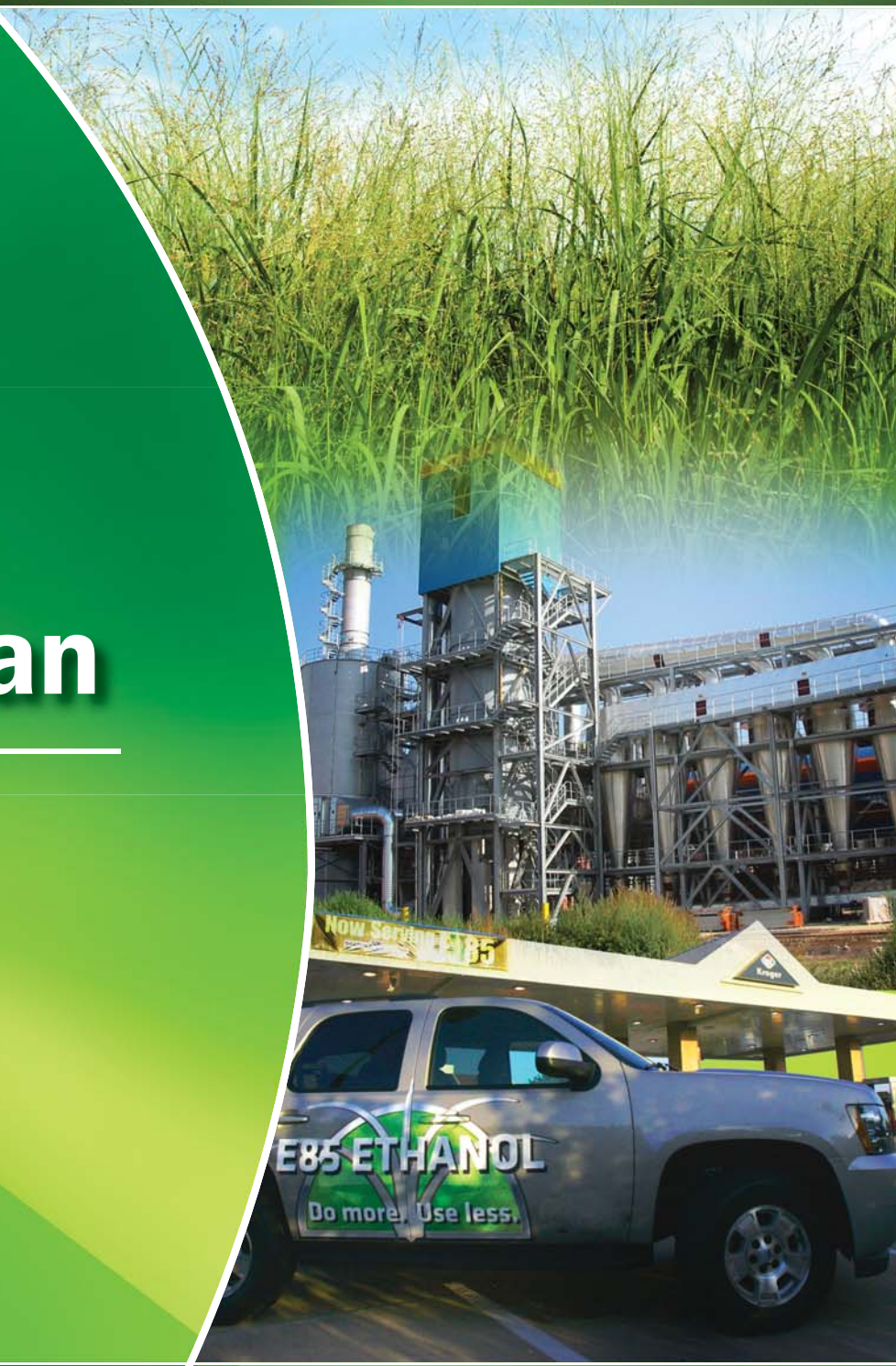
**Biomass Research and Development Board**

*Leading the Federal Interagency Biomass Research and Development Initiative*

# National Biofuels Action Plan

**October 2008**

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# This document was developed through the efforts of the Biomass Research and Development Board

For additional information about the Biomass Research and Development Board, please contact the Departments which Co-Chair the Board: U.S. Department of Agriculture (USDA) and U.S. Department of Energy (DOE).

Office of the Assistant Secretary Energy Efficiency and Renewable Energy (EERE), DOE at (202) 586-9220. The DOE EERE website is located at http://eere.energy.gov/

Office of the Under Secretary for Rural Development, USDA at (202) 720-4581. The USDA Rural Development website is located at http://www.rurdev.usda.gov/

The Biomass Research and Development Initiative (BRDi) website provides information about the Board, the Technical Advisory Committee (TAC), and the Initiative. The BRDi website is located at http://www.brdisolutions.com

The interagency Biomass Research and Development Board was created by the Biomass Research and Development Act of 2000 and is comprised of numerous Federal Departments and agencies.

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# Current National Fuel Challenges

America has one-third of the world's automobiles (230 million) and uses twenty-five percent of the world's oil. The American economy depends on liquid transportation fuels, principally derived from petroleum, to power our cars, buses, trucks, locomotives, barges and airplanes. Use of these fuels has given rise to energy security concerns, contributions to climate change and other environmental challenges. In the absence of alternatives to petroleum products, the Energy Information Administration projects that reliance on foreign producers for oil will increase 30% through 2030, and our transport sector's greenhouse gas emissions will grow by nearly 40% (see AEO 2007 tables 11 and 18). Action is needed now to ensure that viable petroleum alternatives are developed in conjunction with efficiency improvements to address these growing concerns.

## Administration Action

Biofuels is one of the Administration's near-term strategies to address energy security and climate change. In his 2006 State of the Union Address, President Bush declared that America "is addicted to oil" and rolled out the Advanced Energy Initiative (AEI), which included increased research funding for cutting edge biofuel production processes. In early 2007 President Bush announced the "Twenty-in-Ten" initiative, a plan to reduce gasoline consumption by 20% in 10 years. A major element of the plan was a request that Congress mandate an increase in domestic renewable and alternative fuels production to 35 billion gallons per year (BGY) by 2017.

Congress responded in December 2007 by passing a Renewable Fuel Standard (RFS) as part of the Energy

***Figure 1:*** *U.S. petroleum production capacity and demand*

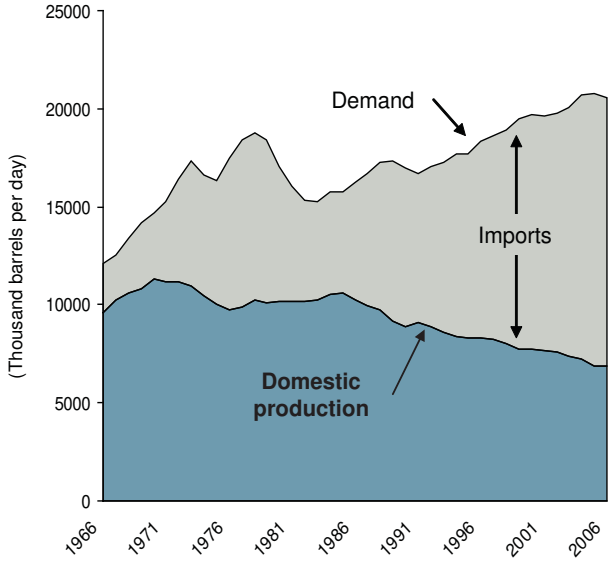
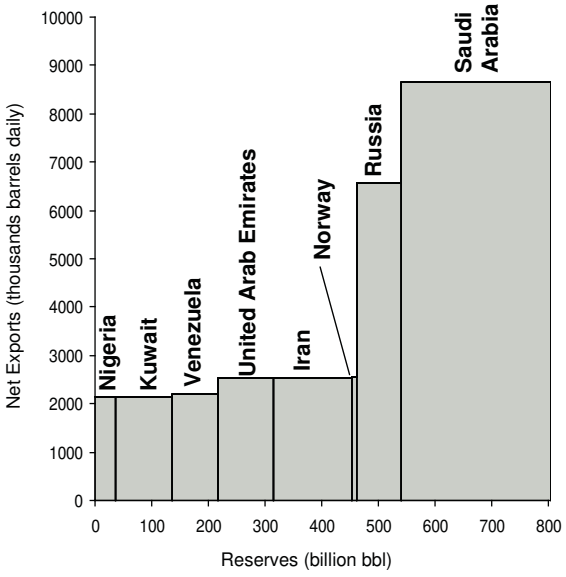



***Figure 2:*** *Top eight world-wide countries for petroleum reserves and net exports*




*Source: EIA Top World Oil Producers & Consumers. Available at http://www.eia.doe.gov/emeu/cabs/topworldtables1_2.htm; BP Statistical Review of World Energy, 2007*

Independence and Security Act (EISA) of 2007 that the President signed into law. The RFS requires 36 BGY of biofuels by 2022, and includes specific provisions for advanced biofuels, such as cellulosic ethanol and biomass based diesel contributions that pave the way for advanced technologies.

Also in 2007, the Bush Administration proposed a Farm Bill that included $1.6 billion in new renewable energy and energy efficiency-related spending at the U.S. Department of Agriculture (USDA), including $210 million to support loan guarantees for cellulosic ethanol projects. In May 2008, Congress passed the 2008 Farm Bill, titled the Food, Conservation, and Energy Act of 2008, with just over $1 billion in mandatory funding for such energy activities.

Meanwhile, Federal agencies have taken major steps since 2006 to implement the AEI. The Department of Energy (DOE) has announced plans to invest nearly $1 billion in partnership with the private sector and academia to research, develop, and deploy advanced biofuel technologies by 2012. This includes up to $272 million for commercial-scale biorefineries, up to $240 million for demonstration scale biorefineries working on novel refining processes, and more than $400 million for bioenergy centers.

## Biomass R&D Board

To help industry achieve the aggressive national goals, Federal agencies will need to continue to enhance their collaboration. The Biomass Research and Development (R&D) Board was created by Congress in the Biomass Research and Development Act of 2000, as amended, "to coordinate programs within and among departments and agencies of the Federal Government for the purpose of promoting the use of bio-based fuels and bio-based products by (1) maximizing the benefits deriving from Federal grants and assistance; and (2) bringing coherence to Federal strategic planning." The Board is co-chaired by senior officials from the Departments of Energy and Agriculture and currently consists of senior decision-makers from the DOE, USDA, Treasury, Transportation (DOT), Interior, Commerce, Defense (DoD), Environmental Protection Agency (EPA), National Science Foundation (NSF), Office of the Federal Environmental Executive, and the President's Office of Science and Technology Policy.


***Figure 3:*** *The biofuels supply chain*

## The Board's Action Plan

This Action Plan outlines areas where interagency cooperation will help to evolve bio-based fuel production technologies from promising ideas to competitive solutions. In developing the plan, the Board used a five part supply-chain framework (see Figure 3) to identify Board action areas:

- **Feedstock Production** comprises the cultivation of biomass resources such as corn, crop residues, and woody residues used as raw material inputs for biofuels production and is discussed in Action Area 2: Feedstock Production.
- **Feedstock Logistics** consists of harvesting or collecting feedstock from the area of production, processing it for use in biorefineries, storing it between harvests, and delivering it to the plant gate. The Board addresses these issues in Action Area 3: Feedstock Logistics.
- **Conversion** is the transformation of the processed feedstock to liquid fuels. Currently, cellulosic ethanol and other technologies essential to achieving the EISA production targets are too costly to compete effectively in the marketplace. Because the pace of technological breakthroughs required to lower costs is inherently uncertain, the availability of advanced technologies to contribute to the EISA goal on an economically and ecologically sustainable basis cannot be assumed. The Board addresses these R&D issues in Action Area 4: Conversion Science and Technology.
- **Distribution** is the transfer of the fuel from the biorefinery to the point of retail sale. A network of trucks, trains, barges, blending and storage terminals, and, possibly, pipelines, must be able to handle significant volumes safely and economically. The Board's approach to meeting these challenges is outlined in Action Area 5: Distribution Infrastructure.
- **End Use** is the purchase of biofuels by the consumer for use in either traditional vehicles at low level blends or vehicles that are specially modified to accommodate higher biofuels blends. Action Area 6: Blending describes the need for increasing blending from E10 to meet EISA, articulates the challenges to doing so, and describes activities the Board has undertaken in this area including the Board's statement on intermediate blends.

In addition, the Board has identified two crosscutting action areas:

- Supporting the **sustainability** of biofuels production and use, such that the social, economic, and environmental requirements of Americans can be met now and into the future. Action Area 1: Sustainability explores this theme;
- Ensuring the **environment, health, and safety** of the public and those working at all stages of the supply chain as new fuels and processes come into use. These topics are explored in Action Area 7: Environment, Health, and Safety.

In the final section, Moving Forward, the Plan draws these individual actions into a cohesive vision for allowing industry to deploy advanced technologies in the market and achieve significant production scale in the next 15 years.

# Board Action Area 1: Sustainability

As President Bush recently noted in a major address to the renewable energy community, the production volumes specified by EISA are not just goals; they are mandatory requirements. He further added that these volumes are needed for the "sake of economic security, national security, and for the sake of being good stewards of the environment." The Federal government is playing a vital role in achieving all of these objectives by mobilizing teams of the best and brightest scientists from all agencies.

A key goal of the National Biofuels Action Plan is to maximize the environmental and economic benefits of biofuels use by advancing sustainable practices and improvements in efficiency throughout the biofuels supply chain from feedstock production to final use. The Board aims to provide the interagency leadership to steer biofuels development on a sustainable path through the compilation and evaluation of biofuels sustainability criteria, benchmarks and indicators. The Board activities will promote close coordination among federal and state agencies and industry to identify best agricultural and land use practices and the most efficient production, conversion, transportation and storage systems that assure economic growth and viability of the biofuel system while protecting ecosystem and human health.

## Historical Context

"Sustainable" as defined by Executive Order 13423 means to "create and maintain conditions under which human and nature can exist in productive harmony, that permits fulfilling the social, economic, and other requirements of present and future generations of Americans." The EISA amendments to the RFS program promote sustainability by (1) directing that significant reductions in greenhouse gasses be achieved for different feedstocks; (2) requiring that biofuels production not adversely impact the environment or natural resources; (3) focusing on the development of cellulosic and other feedstocks which will promote the sustainable production of biofuels; (4) stipulating that every 3 years EPA assess and report to Congress on environmental impacts of biofuel systems.

## *Biomass R&D Board Actions*

As demonstrated by EISA and domestic environmental, agricultural, and conservation policies, the U.S. is an international leader in promoting sustainable biofuels production. The Board will continue its focus on active issues by receiving briefings on key aspects of United States policy including EPA methodologies for greenhouse gas lifecycle analysis conducted under its RFS requirements and the State Department's involvement in the Global Bioenergy Partnership. To further advance its leadership, the Board is:

- Defining, by November 2008, a set of science-based national criteria and identifying science-based indicators to assess sustainable production of biofuels across the biofuels supply chains. These criteria and indicators will be coordinated with ongoing international activities, and will be used to evaluate the environmental, economic, or social performance of biofuels production and use.
- Establishing a Sustainability Interagency Working Group led by DOE, USDA, and EPA, with participation from other agencies, to facilitate strategic planning and coordinate Federal activities; interface with industry and environmental groups; coordinate EISA studies across different agencies; and define and evaluate sustainability criteria, benchmarks and indicators.
- Planning a series of workshops with internal and external stakeholders. Internal workshops will inventory key research efforts in the area of sustainability; identify relevant models, and identify strengths and weaknesses of existing models and gaps. External workshops will involve discussions of analytical and modeling efforts to address pressing issues/challenges, and also inform R&D priorities through dialogues between decision-makers and scientists.

# Board Action Area 2: Feedstock Production

The rapid growth of the biofuels industry has been driven by private sector innovation. To sustain that growth it is essential for the Federal government to work in partnership with the private sector to achieve improvements across feedstocks likely to be in use over the near- and longer-terms:

- **First generation** feedstocks include corn for ethanol and soybeans for biodiesel. These feedstocks are currently in use and their yields have been increasing.
- **Second generation** feedstocks consist of the residues or "left-overs" from crop and forest harvests. They show much promise for near-term adoption with the development of cellulosic conversion technologies.
- **Third generation** feedstocks are crops which require further R&D to commercialize, such as perennial grasses, fast growing trees, and algae. They are designed exclusively for fuels production and are commonly referred to as "energy crops". They represent a key long-term component to a sustainable biofuels industry.

Federal agencies are conducting R&D into high-yield biomass systems and dedicated energy crops that do not disrupt current production paradigms and sustain and enhance the critical natural resource assets required for their production (e.g., water, air, and soil). They are also developing dedicated bioenergy crops through traditional breeding and advanced biotechnology.

## Next Steps

Interagency studies suggest that the U.S. has enough indigenous biomass available to meet the EISA targets. However, key activities need to take place in order to do so:

- Environmental implications and balance between food, feed, and fiber, need to be considered as use of first generation feedstocks (e.g., oilseeds and grain) increases. Environmental implications, such as the effect of feedstock production on soil, water and air quality, and market implications of increased production of feedstocks used for biofuels, for food, feed, and fiber, need to be considered as use of first generation feedstocks (e.g., oilseeds and grain) increases.
- Utilization of second generation feedstocks should sustain and enhance water and air quality and other ecosystem services. The availability and cost of these feedstocks need to be inventoried to qualify plant siting opportunities.
- Third generation feedstocks should be developed to increase drought and stress tolerance; increase fertilizer and water use efficiencies; and provide for efficient conversion.
- Improvements in the yields of all feedstocks will be necessary to support future targets.

## Biomass R&D Board Actions

- The Board has commissioned an interagency feedstock working group to address feedstock availability and cost, sustainability, and greenhouse gas emissions from feedstock activities. The group initially delivered, in June 2008, a feedstock availability and cost study to provide perspective on likely feedstock costs associated with meeting biofuels production targets.
- Another feedstock working group will develop a long-term integrated feedstock research plan across the Federal government by December 2008 to promote enhanced coordination and collaboration.
- The Board will use this information to address the impact of current regulatory processes on the introduction of modified energy crops and to work with farmers and foresters to increase acceptance and introduction of new crops and trees.
- The Board also seeks greater collaboration with private sector researchers, academia, and state governments, as well as international partners and agencies not currently represented on the Board to ensure leveraging of existing funds. As a first step, Federal agencies including EPA, DOE, USDA and NSF will inventory their current partnerships in these areas in order to develop an engagement plan by November 2008.
- The Board will further promote interagency knowledge sharing by expanding the USDA-DOE scientist exchange program to include the NSF and other agencies in the near future.

# Board Action Area 3: Feedstock Logistics

The vast expansion in biofuels production and use mandated by EISA will require the development of new methods and equipment to collect, store, and pre-process biomass in a manner acceptable to biorefineries. These activities, which constitute as much as 20% of the current cost of finished cellulosic ethanol, are comprised of four main elements:

- **Harvesters & collectors** that remove feedstocks from cropland and out of forests.
- **Storage facilities** that support a steady supply of biomass to the biorefinery, in a manner that prevents material spoilage.
- **Preprocessing/grinding equipment** that transform feedstocks to the proper moisture content, bulk density, viscosity, and quality.
- **Transportation of feedstocks** from the field to the biorefinery (as noted in Board Action Area 5: Infrastructure).

Federal agencies are actively collaborating with universities and industry to address this critical segment of the biofuels supply chain. Despite the important role of logistics and the relative immaturity of the needed equipment, to date this area of the supply chain has received limited Federal attention. Increased attention and R&D effort will be required for this supply chain element to achieve targets for delivered biomass.

## Next Steps

Highly effective process management must be integrated with specialized equipment to ensure feedstocks maintain quality, consistency, and reliability of supply over time, while maintaining a reasonable delivered cost. However, natural irregularities of the agricultural system, including year-to-year variations in production, crop rotations, and maintenance of soil nutrients over the long term make cost-cutting measures a challenge. The hurdles that must be overcome fall into two main categories:

- **Logistics enterprise design & management:** The design of feedstock collection, storage and preprocessing systems will vary based on feedstock type, regional geography, and system ownership structures. The challenge is to reduce labor and fuel costs which constitute virtually all the expenses in this supply chain element.
- **Technology development:** New technologies are required to support efficient, economic, and sustainable biomass collection and handling. These include creative approaches to moving feedstocks from field to plant, such as sending slurry through dedicated pipelines, single pass harvesters for agricultural residue collection during commodity crop harvest and in-forest grinders to enable forest residue densification at time of collection. Equipment is being developed and tested by industry and academia to facilitate the collection of these new biomass resources.

## *Biomass R&D Board Actions*

- The Board will facilitate collaboration to develop and deploy logistics systems that can supply cellulosic feedstocks to demonstration facilities currently planned for construction. An active interface with private sector partners will be critical to the success of this research. A working group consisting of the USDA, DOE, and other agencies will lead a planning process to develop milestones culminating in the implementation of logistics systems demonstrations in partnership with industry.
- The Board will ensure that consideration of feedstock logistics issues is integrated into the work of both the Feedstock Production working group (Board Action Area 2) and the Board's Transportation Infrastructure activities (Board Action Area 5).

# Board Action Area 4: Conversion Science and Technology

Although R&D on cellulosic ethanol has made progress in reducing estimated conversion costs (see Figure 4), production costs remain too high for biomass-based fuels to compete in the marketplace. Transformational breakthroughs in basic and applied science will be necessary to make plant fiber-based biofuels economically viable. For example, one key barrier is the natural "recalcitrance" or resistance of plant fiber to break down into sugar intermediates. The scientific and technological challenges here are formidable. Significant work is needed to better understand plant cell walls, where the plant fiber or lignocellulose is embedded, to enable cost-effective breakdown and deconstruction of plant material. The biotechnology revolution -- with its powerful new tools of genomics and systems biology -- holds promise for developing the biological knowledge at the system, cellular, and molecular level that could enable us to re-engineer plants, enzymes, and microbes to overcome recalcitrance.

Another key barrier is to understand how plant material breaks down thermally. In addition, there is potential for new progress in chemical and thermochemical conversion processes through improved catalysis. In short, significant transformational basic research and applied R&D will be necessary to meet the challenge of developing cost-effective, commercially viable conversion technologies that will be needed to support a major move to cellulosic biofuels.

To date, researchers have focused predominantly on cellulosic ethanol, and ethanol is likely to be the first cellulosic biofuel to become commercially available. But the potential also exists to produce other fuels including higher alcohols, "green" gasoline and diesel, and aviation fuels produced via enzymatic and microbial and/or chemical catalytic processing of biomass. Significant issues of feasibility, cost, and scalability remain. Yet such advanced biofuels would have numerous advantages, for example, having energy content comparable to current petroleum based fuels, and easier integration into the existing fuel infrastructure.

## Next Steps

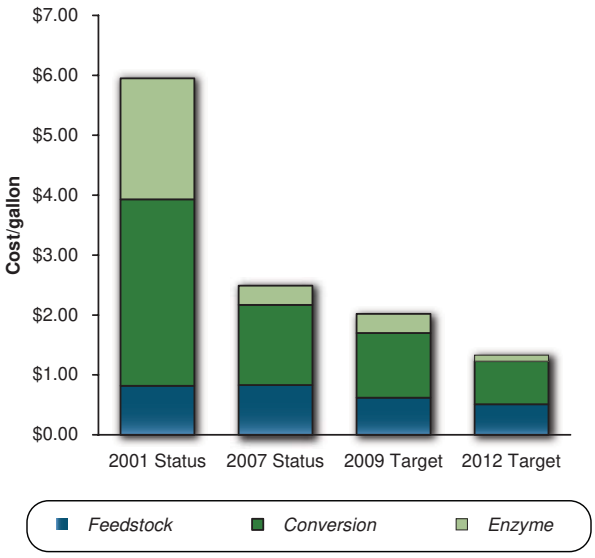
- Developing the knowledge of plants, microbes, and enzymes at the system, cellular, and molecular levels so as to enable re-engineering of these biological systems to substantially reduce conversion costs and increase product yields.
- Developing technologies to enable co-production of marketable fuels and value-added co-products that can improve overall production economics.
- Discovering and developing better technologies for the production of hydrocarbon fuels from lignocellulosic biomass, utilizing microbial, thermochemical, or catalytic processes.
- Addressing fundamental issues of catalysis in the gas and liquid phases, including characterization and durability.
- Addressing the feedstock-conversion interface with the ultimate goal of robust utilization of regionally diverse, multiple, variable, and potentially complex feedstocks.
- Optimizing processes to make technologies economically viable on a small scale.
- Identifying processes and innovations achieved in related industries, such as petroleum refining that can be leveraged to improve the performance of biofuel conversion pathways.

## Biomass R&D Board Actions

The Board has established an interagency working group to guide the exploration of concepts capable of leading to cost-effective and commercially viable processes for converting cellulosic and other forms of biomass to biofuels, including: ethanol; higher alcohols; and green gasoline, diesel, and aviation fuels. The interagency working group is comprised of NSF, DOE, USDA, EPA, DOD, and other agencies. Immediate actions are as follows:

- The Biomass Conversion Interagency Working Group (BCIWG) developed and implemented mechanisms to improve interagency coordination, promote interagency knowledge sharing, and track on-going biomass conversion Research, Development, and Deployment (RD&D) across the Federal sector in May 2008.
- The BCIWG will also develop a comprehensive, integrated 10-year federal RD&D biomass conversion plan that includes agency roles, goals and key milestones and identifies gaps by December 2008.

***Figure 4:*** *2012 cost competitive target and status (biochemical)*




*Source: DOE EERE Office of the Biomass Program, Multi-year Program Plan, Appendix C.*

# Board Action Area 5: Distribution Infrastructure

The national fuel transportation and storage infrastructure must accommodate the current and future growth of domestic biofuels production and transportation. Future production goals envision wider use of a variety of fuels, the production of which is currently centered in the Midwest and other rural areas. However, fuel demand is currently concentrated in large population centers on the east and west coasts. As a result, expanded biofuels production may require transportation of fuels and feedstocks over significant distances.

These current geographical dislocations between supply and demand may necessitate increasing the capacity of existing modes of biofuel transport (rail, truck, barge) and possibly adding new ones. Pipelines, which are considered the least expensive means of safely transporting bulk fuel shipments, may prove to be an economical biofuels transportation solution – provided various technical issues such as stress corrosion cracking can be overcome. Also, infrastructure location and configuration may not be optimal for interconnection of feedstocks, biorefineries, and consumer markets.

Other infrastructure upgrades will also be required, including expanded blending terminal storage capacity, retail infrastructure such as underground storage tanks, as well as seal and gasket materials capable of handling higher biofuels blends. One of the most significant hurdles to retail expansion is the current lack of an Underwriters' Laboratory certification for pumps dispensing blends of E15 or higher. Absent this certification, large operators of fuel pumps ranging from the Postal Service to large retailers will be reluctant to sell E85 or any other approved intermediate blend.

DOT is leading the design of frameworks in which the development of safe, adequate, and cost-effective biofuels transport infrastructure can occur. One of its chief initiatives is a Joint Industry Project whose objective is to determine the effects of ethanol blends on pipelines and storage tanks. DOT also has efforts underway to assess the infrastructure capacity requirements necessary to accommodate additional biofuels transport. DOT and USDA are collaborating to determine the impact of biomass transportation costs on feedstock economics.

## Next Steps

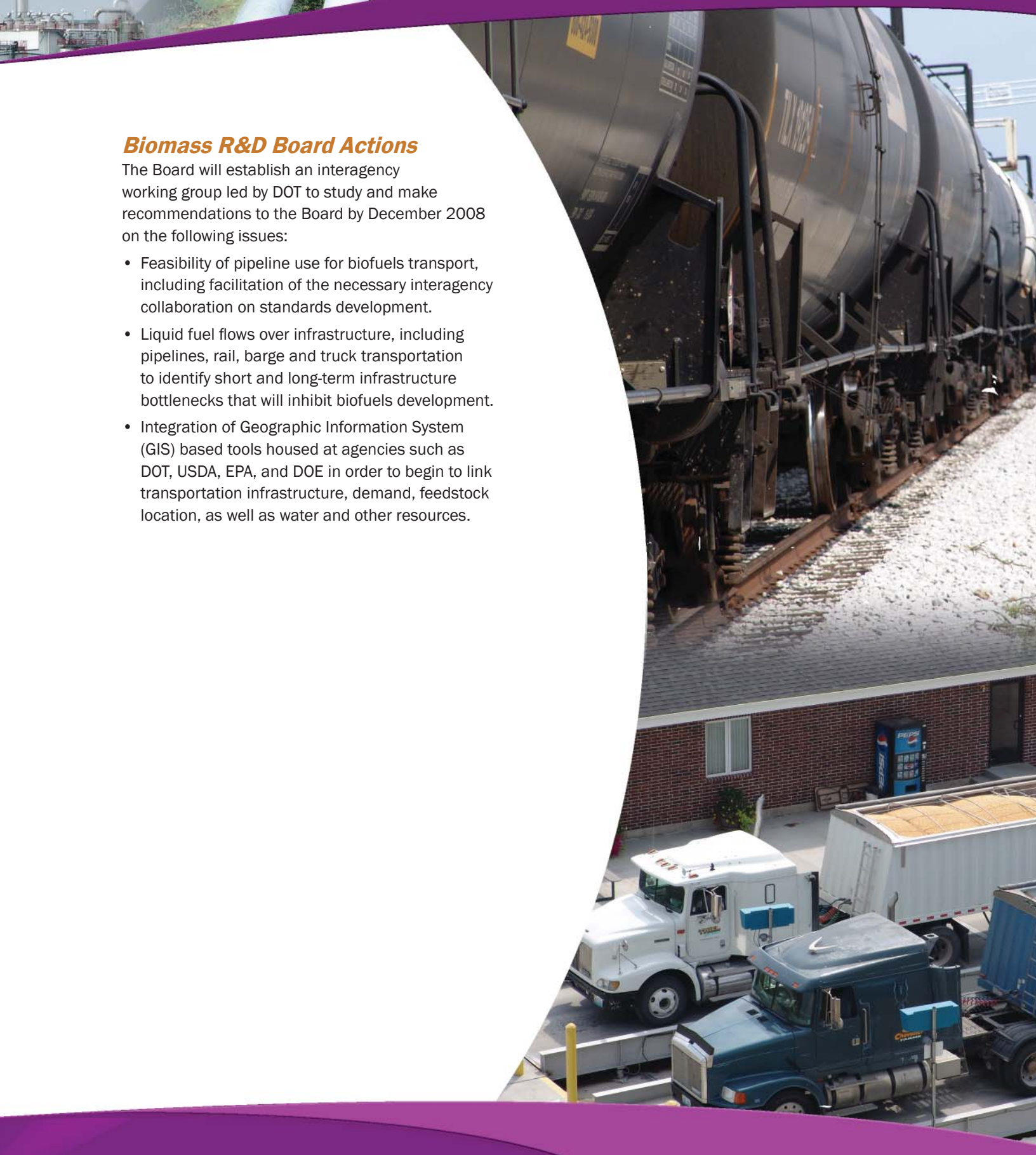
The future biofuels infrastructure must address each of the following areas:

- **Capital:** Appropriate regulations and policies need to be put into place to attract adequate capital for needed infrastructure growth.
- **Corrosion:** The physical properties of ethanol, biodiesel, and other biofuels may require modifications to existing infrastructure as well as new, specially-designed systems to ensure safe transport.
- **Capacity:** Existing infrastructure will need to be optimized to handle increased liquid fuels throughput. Over the longer term, dedicated infrastructure may be necessary to safely and efficiently transport additional volumes of biofuels. Since the biofuels industry is in its infancy, little is known as to where and in what magnitudes the commodities will flow. This creates challenges to assure that sufficient transport and storage capacity will be available to enable them to do so.

## *Biomass R&D Board Actions*

The Board will establish an interagency working group led by DOT to study and make recommendations to the Board by December 2008 on the following issues:

- Feasibility of pipeline use for biofuels transport, including facilitation of the necessary interagency collaboration on standards development.
- Liquid fuel flows over infrastructure, including pipelines, rail, barge and truck transportation to identify short and long-term infrastructure bottlenecks that will inhibit biofuels development.
- Integration of Geographic Information System (GIS) based tools housed at agencies such as DOT, USDA, EPA, and DOE in order to begin to link transportation infrastructure, demand, feedstock location, as well as water and other resources.



# Board Action Area 6: Blending

As ethanol production ramps up to meet renewable fuel levels required by the new RFS, we must ensure that retail markets can deliver large volumes of ethanol to U.S. consumers. The E10 market will be saturated in the next few years and the number of E85 fueling stations and flex-fuel vehicles (FFVs) will likely not grow fast enough to accommodate the higher volumes of ethanol. One potential option for increasing U.S. market opportunities is to raise the amount of ethanol allowed in gasoline to beyond 10 percent (see Figure 5). In order to allow E15, E20, or other intermediate blends* to be used in regular vehicles -- that is, non-FFVs -- we must first understand how these fuels could affect emissions, catalyst durability, driving performance, and materials compatibility, among other factors.

To that end, DOE, in partnership with the EPA, is undertaking an Intermediate Blends Test program to evaluate the potential impacts of intermediate blends on the existing vehicle fleet as well as on smaller engines such as those in lawn mowers, tractors, and other small off-road engines. This program will begin to provide the data needed for Federal fuel registration and approval for the use of intermediate blends of ethanol and gasoline in today's vehicles.

Further increasing the demand for blended ethanol can be expedited by resolving inconsistencies in state interpretations of American Society for Testing and Materials (ASTM) fuel standards when ethanol is blended with gasoline. It will also be important to ensure that the distribution infrastructure is in place to effectively deliver intermediate blends to consumers.

## Next Steps

Necessary steps to increase the availability of blended ethanol:

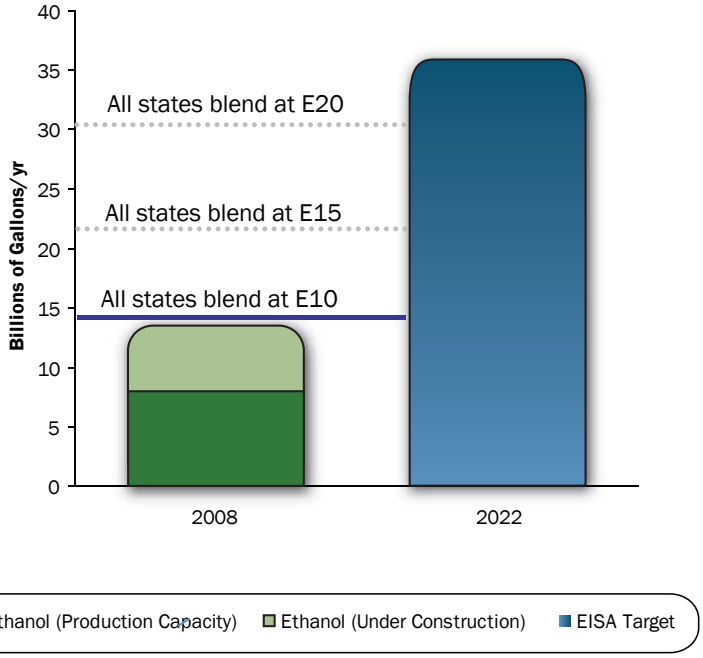
- Air quality impacts of higher blends need to be quantified. While E10 helps reduce overall vehicle emissions of criteria pollutants, the impact of higher blends on emissions is not currently well understood. There is a need to understand how higher fuel blends may affect state and local air quality situations or attainment of National Ambient Air Quality Standards (NAAQS).
- Ethanol use and limitations on use may be a function of the fleet's ability to legally and technically absorb higher volumes of ethanol, and that is a function of both fuel and vehicle allowances and constraints.
- Materials used in current infrastructure (tanks, piping, dispensers, etc.) may not be compatible with higher blends.

## *Biomass R&D Board Actions*

- The Board has approved a statement on ethanol blend policy (see Figure 6).
- As noted, the Board's member agencies are conducting an interagency testing program to evaluate the impact of intermediate blends on vehicle emissions and material compatibility to support potential fuel supplier waiver applications. Initial test results are targeted to be available in Fall 2008.
- The Board will work with state and local agencies to ensure full national penetration of E10 through resolving obstacles posed by state regulations and the private sector.

** E10, E15, E20 and E85 denote the percent of ethanol blended with gasoline (10%, 15%, etc.).*

***Figure 5:*** *Volumes of ethanol absorbed by several blends*




Source: Renewable Fuels Association for ethanol capacity; EIA AEO for gasoline consumption (140 billion gallons of motor gas/yr).

Note: E15 and E20 testing is underway; these blends are not currently authorized for use.

# Figure 6: Board Ethanol Blends Policy Statement

## Alleviating Oil Dependency and Greenhouse Gas Emissions on an Accelerated Basis Through Biofuels Deployment

The interagency Biomass Research and Development Board, on behalf of its respective agencies, is committed to the President's goal of reducing petroleum-based gasoline usage in the United States by 20 percent in the next 10 years ("the Twenty-in-Ten" initiative). Our national fuel infrastructure must accommodate the current and future growth of domestic biofuel production and delivery. As we develop the technology for the next generation of biofuels, it is essential that we enable both full utilization of increased biofuels production and nationwide retail access, while minimizing disruptions, cost and infrastructure challenges, and potential environmental, health and safety impacts. In addition to the present and projected growth of E10 and E85 sales, federal fuel registration and national market access for intermediate ethanol blends of gasoline (defined as blends between 10% and 85% ethanol, e.g., E12, E15, E20) that meet applicable statutory and regulatory requirements represent a critical pathway to meet the Twenty-in-Ten goal. The Board will continue to monitor and assess closely issues regarding the development, availability, and potential impacts of intermediate ethanol blends of gasoline.

# Board Action Area 7: Environment, Health and Safety

Helping develop and maintain a world-class safety, public health, and environmental protection record is one of the Federal government's most important roles in supporting the industry's future growth. The Federal government has a number of comprehensive and proactive public health, safety, and environmental protection programs involving many agencies. As biofuels come into greater contact with our infrastructure as their use increases, and as innovation produces fuels that are not currently in wide use (such as green hydrocarbon fuels or biobutanol), these programs will need to understand and manage any associated risks. This will require maintaining and upgrading a wide range of expertise including biofuels, fire protection, human health exposure, environmental, occupational safety and health and transportation.

## Next Steps

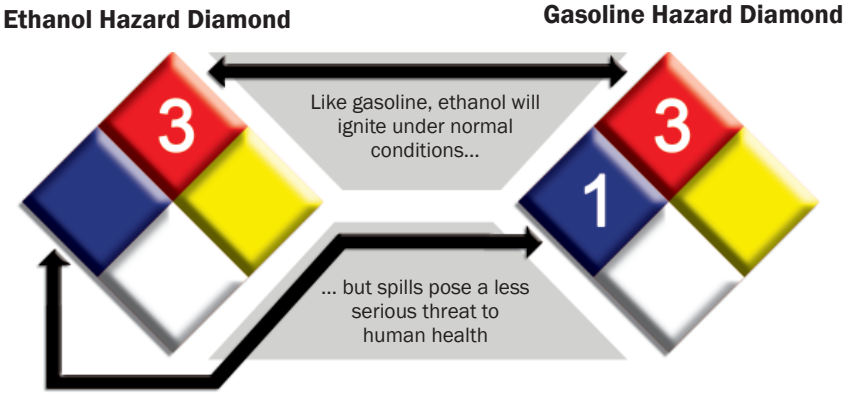
Biofuels have been safely produced, transported, and used in the U.S. for decades and have hazard characteristics similar to those of gasoline (see Figure 7). While many of the characteristics of various biofuels are already known and documented in material safety data sheets, the broader application of these fuels, as well as entry into service of advanced fuels not currently in use, will require attention to anticipate risks, control potential hazards, and prevent mishaps. This requires an approach to health and safety that comprehensively protects public health and worker safety, while doing so without excessively constraining businesses serving the biofuels supply chain.

## *Biomass R&D Board Actions*

The Board will establish an interagency working group to benchmark agricultural and biofuels industry successes and practices.

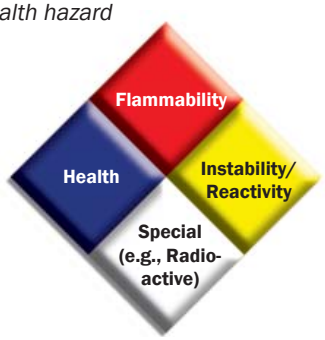
- The group will inventory the Federal government's activities and areas of jurisdiction with respect to public health, safety, and environmental protection.
- It will review and summarize potential public health, safety, and environmental issues related to the life-cycle of biofuels and identify research needs and potential mitigation options.
- This information will be used to conduct outreach to the public, industry, and other entities in the biofuels economy as well as to prioritize Federal government research in these areas.

***Figure 7:*** *Ethanol and gasoline hazard diamonds*




*Source: National Fire Protection Association*

*Each corner of the diamond represents a health hazard*




*Each color is rated on a scale from 0 (no hazard; normal substance) to 4 (severe risk)*

# Moving Forward

Expanding biofuels usage to 36 BGY over 15 years on a sustainable basis will be a key component to America's movement toward clean, affordable, and secure energy solutions. Success will require a coordinated approach between the public and private sectors to advance biofuel technologies and create market conditions that will enable their use. A combination of policy and R&D (public and private investment) has already led to progress toward achieving the 2022 requirement. Current and near term production of corn-based ethanol and biodiesel are progressing to meet market demand. However, meeting the 2022 goal, as well as interim targets, will require development of advanced biofuel technologies and the construction of technologically innovative biorefineries utilizing these technologies. The scientific and technological challenges entailed in meeting these ambitious national goals are significant, and both transformational basic science research and applied research will be essential to break through the considerable technological barriers at present to producing cellulosic biofuels cost-effectively on a commercial scale. The federal government is devoting considerable resources to this research.

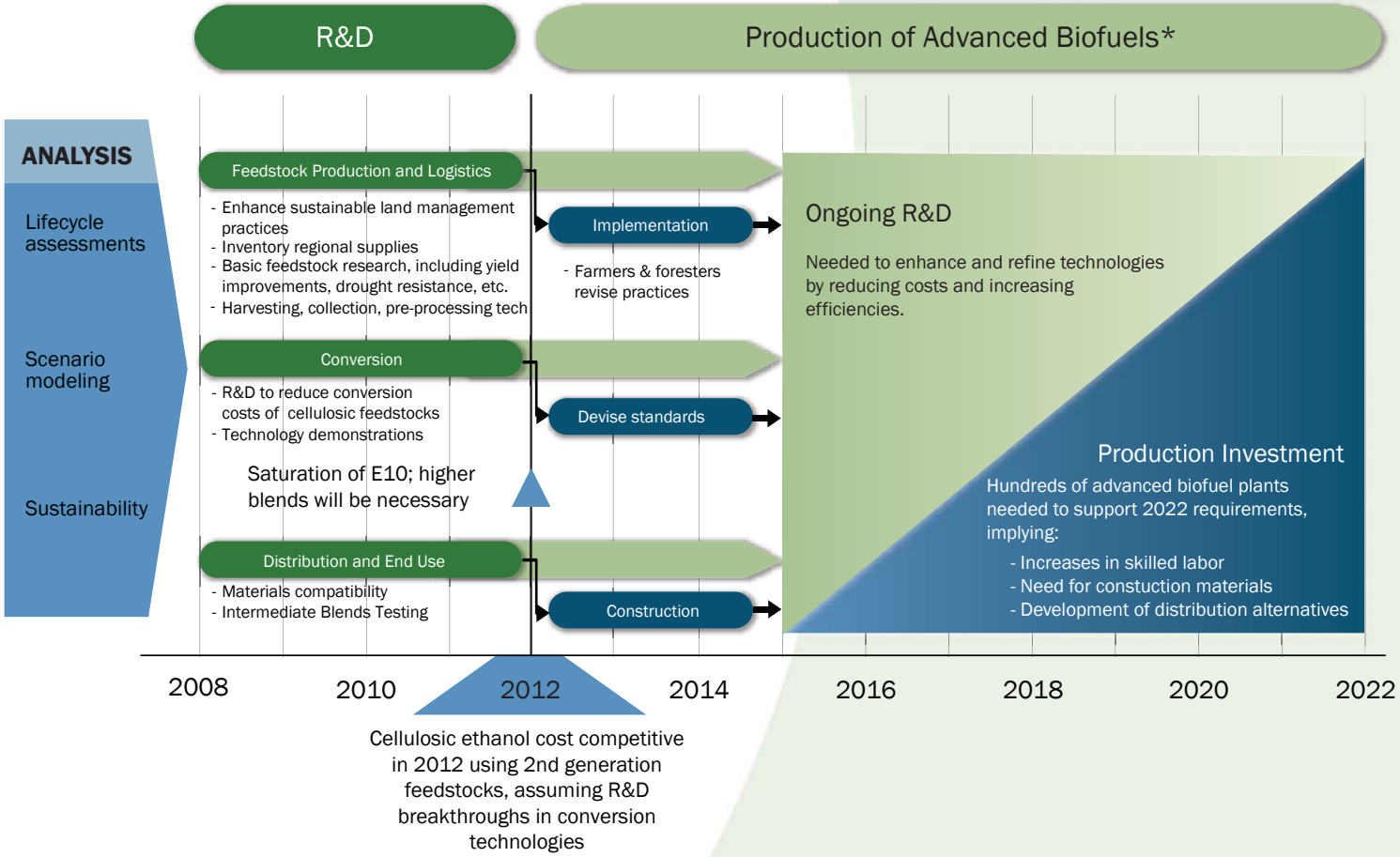
The path to achieving the 2022 goals requires a comprehensive review of all aspects of the biofuels supply chain to identify critical interdependent activities and their sequencing. A top-level perspective, as depicted in Figure 8, suggests the following as critical near term areas to enable advanced biofuels development and market penetration:

- **Feedstock Production and Logistics:** R&D advancements in crop production, the use of multiple feedstocks, and increased yields must be developed and implemented to meet biorefinery needs. Also, advancements are needed in harvesting, collection, storage, and pre-processing for multiple feedstocks.
- **Conversion:** Advanced conversion technologies must progress to attract commercial production investment by 2012. Current public/private demonstration plants are underway to prove the viability of multiple advanced technologies using multiple feedstocks. Major increases in commercial construction will need to start on or about 2012 to justify acquisition of capital assets and mobilization of the required resources including workforce.
- **Distribution and End Use:** The increased production capacity will require full saturation of the E10 blending market along with expansion into intermediate blends and further E85 consumption. In addition, R&D on corrosion and other issues related to environment, health and safety must be resolved to support industry growth. Finally, potential expansion of transport and distribution networks to move the fuel to demand centers across the U.S. must be evaluated to ensure needed upgrades can be initiated in the near term.

Progress against these tight timelines will require an adequate supply of skilled technicians, builders, and managers. Human capital development will be important to maintain the pace of biofuels production capacity growth. To meet this challenge, government agencies will need to work collaboratively with university and other partners to assess workforce development needs and respond with well-crafted technical training and advanced science education programs.

Moving forward, the Biomass R&D Board will continue to coordinate Federal agency involvement in biomass R&D, demonstration, and implementation activities to promote the advancement of the biofuels industry. The Board will also reach to the private sector to advance the commercialization of the new technologies to meet the 2022 production requirements.

***Figure 8:*** *Top level advanced biofuels commercialization timeline*




** Advanced biofuels can include 2nd generation cellulosic ethanol, biobutanol, biodiesel, etc.*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